2004

Nutrition and bone health in female athletes : a nutrition assessment for coaches and athletes

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NUTRITION AND BONE HEALTH IN FEMALE ATHLETES

A Nutrition Assessment for Coaches and Athletes

by

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presented in partial fulfillment of the requirements for the degree of

Master of Science

The University of Montana

December 2004

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1-3-05

Date

Whitish, Kimberly D., MS, December 2004 Health and Human Performance

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Adequate nutrition is vital for the development and maintenance of the skeleton. Bone health is determined by many factors including calcium intake, vitamin D and K availability, protein and sodium intake, and overall nutritional status. Diseases of the bone, such as osteoporosis and osteomalacia, have complex etiologies. Providing sufficient nutrients, however, at appropriate periods during the life cycle can minimize their development. The most common and destructive bone disease is osteoporosis, affecting over 44 million Americans, 80% of whom are women (1). Risk factors for low bone mineral density (BMD) in athletic females include low energy intake, eliminated dairy products, disordered eating, low calcium intake, and excessive thinness (2). Because adequate intake of bone-building nutrients is necessary even after the onset of osteoporosis, the benefits of calcium, and other nutrients during adulthood, and the elderly period remain as significant as during the early life period of bone growth and development.

The supplement provides a tool that coaches can use to help them evaluate the dietary practices of their athletes. These tools include a pre/post season quiz, diet assessment, energy expenditure calculators, dietary goals and weight management information, and information about what foods are best to improve and maintain performance and increase bone health. The supplement will help athletes to understand why and how they can change poor dietary behaviors and begin to choose foods that will help to increase their bone mineral density (BMD).

Previous research illustrates the need to educate female athletes on the protective element of a high calcium diet. The foods that contain the highest amounts of calcium are dairy products; unfortunately, many female athletes perceive these as fattening and omit them from their diets in their attempts to lose weight. There is a great need in this population for guidelines and easy to use assessments that can help in the education and improvement of nutritional status.

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ACKNOWLEDGMENTS

First and foremost I pray to God and thank him for giving me the will and strength to get through this. I would like to thank my father and mother Mike and Ginnie Nelson, for supporting me financially and emotionally through this long and stressful time. Thank you Aaron Case for encouraging me to go back to school, applying to graduate school so that I would, and for all your support while I completed my degree.

DEFINITION OF TERMS

Amenorrhea: abnormal, absence, or suppression of menstruation (3).

Bone Mineral Density: a measure of bone density expressed in grams per centimeter squared (area density); used to assess the amount of bone after the developmental period is complete.

Cortical Bone: the compact bone of the shaft that surrounds the medullary cavity of the long bones.

Osteomalacia: a bone disease characterized by a softening of the bones, resulting from a deficiency in calcium salts, found chiefly in adult women; condition of impaired mineralization caused by vitamin D and calcium deficiency. (3)

Osteoporosis: a porous condition; a bone disease characterized by a reduction in bone density accompanied by increasing porosity and brittleness; associated with loss of calcium from the bones; loss of bone tissue to the point that the specific skeletal site is unable to sustain ordinary strains; a specific definition that is based on bone densitometry (3).

Peak Bone Mass: the greatest amount of bone accumulated at any age.

Trabecular Bone (Cancellous Bone): the spongy bone in the knobby ends of the long bones, the iliac crest, scapula, and vertebrae.

CHAPTER 1

INTRODUCTION

Osteoporosis was once considered a disease of the elderly causing tragic accidents such as broken hips and wrists. These injuries often result in admission to an assisted living environment and subsequent dissociation from society. Osteoporosis has become, however, a disease that is afflicting a younger population. Pre-menopausal female athletes are fast becoming the new 'at risk' group for osteoporotic fractures.

Approximately 44 million Americans are affected by osteoporosis; 80% of these are women. Osteoporosis results in 1.5 million fractures annually, at a cost of over $17 billion in health care. Of these osteoporosis-related fractures, 700,000 involve the vertebrae and 300,000 are fractures of the hip, which result in incapacitation, long-term nursing care, and frequently death. In addition, 250,000 are wrist fractures and 300,000 are fractures at other sites. Although incident rates of fractures in the United States (US) are not projected to increase substantially, the prevalence is predicted to increase greatly until 2030 (4).

Nutritional studies continue to be an important element in advancing the understanding of the cause and prevention of metabolic bone disease and osteoporosis. Close nutritional monitoring with athletes and information given to athletes can improve athletic performance and reduce the risk of nutrition related problems (5). Low or inadequate energy intakes in female athletes combined with excessive training can result in a loss of muscle mass, menstrual dysfunction, loss of or failure to gain bone density, premature osteoporosis, and increased risk of fatigue, injury, and illness (2, 6).

Female athletes are under immense pressure to maintain low body fat. These athletes often engage in disordered eating, energy restriction, and harmful dietary and weight control practices. This, in turn, results in the development of amenorrhea, impaired bone health, hindrance of performance, and increased risk of osteoporosis (7, 8). The long term health consequences of energy restriction include poor energy and nutrient intakes, poor nutritional status, decreased resting metabolic rate and total energy expenditure, increased psychological stress, increased risk for exercise induced amenorrhea, and osteoporosis (9).

Female athletes participating in thin-build, endurance, and appearance sports, such as cross country, dance, volleyball, and gymnastics are at risk for the disorders of the female athlete triad, which is a combination of disordered eating, amenorrhea, and osteoporosis (10-12). Prevention of disordered eating practices among these athletes requires appropriate nutritional education, psychological intervention, and behavioral modification, which in turn, will improve amenorrhea and bone loss (7).

Investigators have examined the intimate relationship between dietary calcium and bone mass, and report that consuming adequate calcium between the ages of 20-30 increases bone mass (13-15). A study investigating developmental changes in skeletal mass of adolescent girls and young women under different experimental and ecological conditions support the hypothesis that increasing dietary calcium can improve bone mass and bone density compared to controls (13). Thus, potential gains in bone mass during late adolescence and early adulthood, although small, may be readily achieved through increased dietary calcium intakes (13).

There has been little research done to investigate the benefits of educating female athletes on calcium intake and bone health. More studies should be conducted to determine if assessments would help to increase the dietary practices of female athletes who may be at risk for low bone density.

PURPOSE OF PROFESSIONAL PROJECT

The purpose of this professional project is to provide coaches and athletes with evaluative and informational tools to help improve the overall nutritional health of pre-menopausal female athletes. In addition, this professional project will serve as a supplement to help increase bone density in female athletes who may be at risk for low bone density because of poor dietary and weight control practices.

SIGNIFICANCE OF PROFESSIONAL PROJECT

This project is an important tool for coaches and athletes that is not currently available to them. Previous literature on bone health in female athletes has indicated that this population is at risk for low bone density and osteoporosis partially due to the lack of nutrition knowledge and misinformation. This paper can provide guidance to this at-risk population and help them to increase calcium intake to promote bone health. It can also be used as a tool for other researchers to determine if nutritional interventions are actually improving the dietary practices of female athletes.

CHAPTER 2

REVIEW OF LITERATURE

Adequate nutrition is vital for the development and maintenance of the skeleton. Bone health is determined by many factors including calcium intake, vitamin D and K availability, protein and sodium intake, and overall nutritional status. Diseases of the bone, such as osteoporosis and osteomalacia, have complex etiologies. Providing sufficient nutrients, however, at appropriate periods during the life cycle can minimize their development. The most common and destructive bone disease is osteoporosis, affecting over 44 million Americans, 80% of whom are women (1). Risk factors for low bone mineral density (BMD) in athletic females include low energy intake, eliminated dairy products, disordered eating, low calcium intake, and excessive thinness (2). Because adequate intake of bone-building nutrients is necessary even after the onset of osteoporosis, the benefits of calcium, and other nutrients during adulthood, and the elderly period remain as significant as during the early life period of bone growth and development.

Osteoporosis

Osteoporosis is a disease characterized by low bone mass and micro architectural deterioration of bone tissue leading to enhanced skeletal fragility and increased risk of fracture (16). It is a disease that generally manifests itself late in life and without warning, but it may have its origin in early adolescence, during the period of skeletal growth and peak bone mass (PBM) accumulation. Unlike many diseases that make themselves known through symptoms such as pain, shortness of breath, skin lesions, and fatigue, osteoporosis is silent.

The body sends no signals saying the bones are losing their calcium and, as a result, their integrity. Routine blood samples offer no clues that bone loss is occurring because blood calcium remains normal regardless of bone content, and additional measures of BMD are not typically taken. Osteoporosis occurs when BMD becomes so low (2.5 standard deviations below the mean) that the skeleton is unable to sustain ordinary strains, a condition marked by the occurrence of fractures (17). Deterioration of bone tissue, especially trabecular bone tissue, results in micro fractures, another essential feature of osteoporosis. Loss of bone mass that produces fractures can result from 1) an excessive acceleration of loss, especially after menopause, or 2) a PBM so low that after enough normal wearing down, the bones become fragile and susceptible to fracture. PBM was previously thought to occur during the ages of 20-25, but recent research has shown that by the age of 29, only 90-95% of total PBM is attained, indicating growth is occurring well into age 30 (17-20).

Female athletes are at an increased risk for osteoporosis because they often restrict the amount of calories they are consuming. In addition, female athletes often think that foods that are high in calcium, such as dairy products, are fattening so they decrease their consumption of these foods.

Bone Development and Disintegration

Bone is unique as a living tissue in that it is not only rigid and resistant to forces that would ordinarily break brittle materials, but also light enough to be moved by coordinated muscle contractions (21). Bone has two compartments: the outer, hard shell of cortical bone, and the inner, lacy matrix of trabecular bone. Trabecular bone tissue adds support to the cortical bone tissue shell of the long bones as well as provides a large surface area that is exposed to circulating fluids from the bone marrow. Both can lose minerals, but in different ways and at different rates. The loss of trabecular bone tissue later in life is largely responsible for the occurrence of fractures. The lacy, calcium-containing crystals of trabecular bone give up calcium to the blood when the diet runs short, and they take up calcium again when the supply in the diet is plentiful (22-24).

Stress Injury to the Bone

Stress injuries to bone, or stress fractures, exist on a continuum, involving mechanical as well as hormonal and nutritional factors (25). Stress fractures result from repetitive cyclic loading of bone, which overwhelms the reparative ability of the skeletal system (26). Stress fractures are a serious form of bone injury that commonly occurs in athletes (26-29). A number of risk factors including low BMD, menstrual irregularities, dietary factors, low body weight, inadequate calcium and Calorie intake, disordered eating, female gender, and a prior history of stress fractures have been associated with an increased risk for stress fractures in female athletes (25, 29). One study showed that in athletes with similar training habits, those with fractures were more likely to have lower dietary calcium intakes and lower BMD (28). Other studies have shown similar results (30). Although young athletic men can have low BMD values, female athletes have the greatest risk (2).

The Female Athlete Triad

The female athlete triad is a serious syndrome consisting of disordered eating, amenorrhea, and osteoporosis (10). The term 'female athlete triad' was coined by the American College of Sports Medicine (ACSM) in response to the increase in the number of female athletes participating in sports and the potential medical disorders associated with them (31).

The female athlete triad describes the complex interplay of menstrual irregularity, disordered eating, and premature osteoporosis seen in female athletes (32). The triad is common among female athletes and it often goes unrecognized; the consequences of lost BMD can be devastating. As a result, premature osteoporotic fractures occur, and the lost BMD may never be regained (33). The problems of the triad have aided in the understanding and appreciation of the important interaction of mechanical, hormonal, nutritional, and genetic factors on bone health in the young female athlete (29).

Disordered Eating

Disordered eating refers to a wide spectrum of harmful and often ineffective eating behaviors used in attempts to lose weight or achieve a lean appearance (10). Female athletes, unlike their male counterparts, are particularly likely to develop disordered eating. Part of the reason many athletes engage in disordered eating behaviors may be that they and their coaches have embraced unsuitable weight standards. An athlete's body must be heavier for a given height than a non-athlete's body because the athlete's body is dense, containing more healthy bone and muscle and less fat. Many young athletes severely restrict energy intakes to improve performance; however, they fail to realize that the loss of lean tissue that accompanies energy restriction actually impairs their physical performance (34).

Amenorrhea

Amenorrhea is characterized by low blood estrogen, infertility, and often, bone mineral losses (10). However, not all amenorrheic athletes have low bone mass (10). Some research indicates that depleted body fat contributes to amenorrhea; other studies indicate that the percentage of body fat is not associated with normal menstruation in athletes.

Female athletes who do not have regular menstruation are at a higher risk for osteoporosis because estrogen helps to bind calcium to bone. Female athletes who increase their Calorie and calcium intakes are more likely to improve bone health and decrease their risk of osteoporosis than those who continue to restrict Calorie and calcium intakes.

Osteoporosis

For most people, weight-bearing physical activity, dietary calcium, and the hormone estrogen protect against the bone loss of osteoporosis. For young athletes with disordered eating, amenorrhea, and low calcium intake, strenuous activity can impair bone health (10, 25). Vigorous training combined with inadequate food intake greatly increases the risk of stress fractures today and of osteoporosis in later life. One study reported a lower BMD in athletic women who had stress fractures than among non-injured controls, indicating that stress fractures can be a sign of premature osteoporosis (28).

Osteoporosis is a very serious disease and prevention needs to begin as early in life as possible. If athletes gain the knowledge needed to protect themselves from harmful behaviors, it would seem likely that the risk of osteoporosis will decrease. However, because some athletes feel that foods containing calcium, such as milk, are fattening, they tend to avoid them, not fully understanding the detrimental consequences of their behavior.

Calcium

Calcium appears to have the strongest effect on bone health of all the nutrients because calcium is the mineral that is present in the largest amounts in the body, (35, 36) with 99% of all body calcium present in the bones and teeth. Because bone is a dynamic tissue, there is a constant turnover of bone calcium (37). Calcium acts in concert with vitamins D and K, phosphorus, and magnesium to maintain normal bone structure and function, although there are many nutrients and hormones that affect the body's absorption, retention, and use of calcium (38). Of total calcium ingested, approximately 30-50% is absorbed, and absorption from the gastrointestinal tract is managed largely by need. Thus, the body adapts to decreases in calcium intake by increasing absorption to maintain calcium balance (36).

Calcium Supplementation

Calcium supplementation has been found to increase the amount of bone mass accumulated when amounts above the Recommended Daily Allowance (RDA) are given (13, 39). Although studies have not been conducted on pre menopausal female athletes, research involving supplementation indicates that the gain in BMD in supplemented individuals does not seem to persist after stopping supplementation (17, 40, 41).

Low calcium intake has been linked to an increased risk for osteoporosis. Studies suggest that supplementing pre-menopausal women with calcium significantly reduces bone loss. For example, two studies report that pre-menopausal women who supplemented their daily intakes with either 1,000 mg or 1,500 mg of calcium per day had a significant increase in total body and regional Bone Mineral Content (BMC) and reduced bone loss in the humerus (respectively) (42, 43). Another similar study supplemented peri menopausal women (n=248) for two years with 1,000 mg or 2,000 mg of calcium and found a significant reduced lumbar bone loss and bone turnover in the first year of calcium supplementation (44). A prospective study found that calcium supplementation in the form of dairy products decreased the rate of vertebral bone loss in pre-menopausal women (45).

A meta-analysis examined the effect of calcium intake on bone mass in young and middle aged females in 27 cross-sectional studies and found significant correlations (46). Collective analysis of the results from four intervention studies in pre-menopausal women showed that calcium supplementation of ~1,000 mg per day can prevent the loss of 1% of bone per year at all bone sites except in the ulna (46). These results suggest that healthy pre-menopausal women may lower their risk for osteoporosis by increasing dietary calcium intake.

The bioavailability of calcium supplements varies depending on the type of calcium that is contained in the supplement. One study looked at increasing daily calcium intake from 80% of the RDA to 110% through supplementation with calcium citrate malate. The supplementation resulted in significant increases in spinal and total body bone density in adolescent girls, which translates into protection against osteoporosis later in life (47). Supplementation appears to be the most beneficial in those whose intakes are already low.

For example, a study of 112 post-menopausal women whose usual calcium intake was <400 mg per day showed a significant retardation of BMD loss at the spine, femoral neck, and radius with calcium citrate malate supplementation (48). However, research has not been conducted on pre-menopausal female athletes to determine if BMD can be improved through supplementation.

Calcium Recommendations

Recommendations for the intakes of calcium were made in 1998 by the Institute of Medicine (49). The recommendation for calcium in 19-50 year old individuals is 1,000 mg per day. According to the United States Department of Agriculture (USDA) Household Food Consumption Survey (50), teen and adult women consume considerably less than the current adequate intakes (AI). This finding is consistent in other countries as well (51, 52). Surveys of females between 12 and 30 years of age have shown an inadequate average daily calcium intake of less than 900 mg per day (53). This inadequacy translates into approximately 200-500 mg per day of calcium on average needed for teenage girls and adult women.

Although obtaining calcium from foods is recommended, supplements can also be used. Female athletes who do not consume adequate amounts of calcium in their diet should be encouraged to take a calcium supplement such as calcium citrate malate to increase their bone density.

Vitamin D

Vitamin D_3 is produced photo chemically by the action of sunlight or ultraviolet light from the precursor sterol 7-dehydrocholesterol, which is present in the epidermis or skin of humans, or obtained through dietary intake (54). Vitamin D_3 from the skin is metabolized in the liver to $25(OH)D_3$, which is the major form of vitamin D circulating in the blood (54). Vitamin D is then converted in the kidneys into two dihydroxylated metabolites, which are transported to organs and cause biological responses (54). Vitamin D is required for adequate calcium absorption in the intestine, regulation of serum concentrations of calcium (55, 56) and phosphate (57), and the promotion of bone health (2); it is the most important biological regulator of calcium homeostasis.

Vitamin D is produced in the skin after exposure to sunlight. Humans, therefore, do not have a requirement for vitamin D when sufficient sunlight is available. However, in the absence of sunlight, vitamin D does become an important nutritional factor. It is known that parts of the US population, especially those populations living in the northern US, are exposed to suboptimal levels of sunlight, especially during the winter months (58, 59). Under these and other extreme conditions, vitamin D must be supplied in the diet or supplemented on a regular basis. Any failure to synthesize adequate vitamin D or obtain enough from foods results in a loss of calcium from the bones, which can result in fractures. An inadequate intake of vitamin D leads to reduced calcium absorption and bone loss (60). Diets that are deficient in vitamin D are usually deficient in calcium (60).

It is important for female athletes to have an adequate amount of vitamin D to help with calcium absorption. If exposing their skin to sunlight is not readily available, a supplement might be warranted.

Protein

It is known that urinary calcium excretion rises as protein intake increases (61-63). Whether excess protein depletes bone of calcium may depend upon the ratio of calcium intake to protein intake, but if an individual meets the recommendations for calcium, there is probably sufficient protection for the bones (64). New research suggests that dietary protein may act synergistically with calcium to favorably influence bone health (65). Studies have repeatedly shown that intake of protein, particularly purified proteins from either animal or plant sources, increases urinary calcium excretion (66-68). It has been proposed that dietary protein, especially from animal sources rich in sulfur amino acids, increases endogenous acid production, which is buffered by alkaline salts of calcium from the skeleton (62, 67, 69). Spencer et al. (70), in a series of human metabolic studies, showed that meat or milk protein did not affect calcium excretion, a finding attributed to the phosphorus content of these commonly consumed complex protein sources. Inconsistencies regarding protein's effects on bone health have raised the question of whether or not the type of protein influences the findings. However, there is no overall pattern regarding the effect of animal versus vegetable protein on bone health (71-73). These inconsistencies may be explained by other constituents in foods and in the diet or, in particular, the synergy among nutrients which may have a greater impact on protein's effect on bone than the type of protein (74). The level of calcium intake may explain some of the inconsistent findings regarding protein's effect on the skeleton (65, 75, 76). As mentioned before, excess protein does not appear to harm the skeleton if calcium intake is adequate.

Some investigators have suggested that many women in the US have average calcium intakes that are low and average protein intakes that are high, which may produce calcium losses significant enough to compromise bone health. Others suggest that calcium losses occur when protein intake is high because such diets are typically low in fruits and vegetables and produce acid (62). The skeleton responds to this acidity by giving up its calcium. A 50-milligram increase in urinary calcium loss per day will result in an 18.25-gram loss per year, because the average adult female skeleton contains 750-grams of calcium at its peak, this is a loss of one half of total skeleton stores over the course of her lifetime (62). A recent review of 34 published studies on the effects of protein on osteoporosis risk found a direct connection between hip fracture risk and corresponding protein intakes (61).

High protein intake may increase urinary calcium excretion, but whether or not calcium balance is adversely affected is uncertain due in large part to the presence of other dietary constituents. Female athletes who think that protein is the primary fuel for muscle often consume excessive amounts of protein, which may cause stress on the kidneys. In addition, these athletes may be consuming diets that are low in calcium, which put them at a greater risk for osteoporosis.

Phosphorus

As an inorganic element, phosphorus is second to calcium in abundance in the human body with 85% of the body's phosphorus bound to the skeleton. The primary purpose of dietary phosphorus is to support growth and to replace losses. There has been little research into the role of phosphorus in bone. However, there is concern that excessive amounts may be detrimental to bone. Phosphorus is an essential nutrient and accounts for a significant proportion of bone mineral content, but it is unclear whether changing the level of dietary phosphorus intake has any effect on bone health (77). For example, a rise in dietary phosphorus increases serum phosphorus concentration, producing a transient fall in serum ionized calcium resulting in elevated parathyroid hormone (PTH) secretion and potentially bone resorption (78). The primary function of PTH is to prevent hypocalcaemia by increasing bone resorption of calcium. The hypothesis that excess dietary phosphorus is harmful to bone was tested in young adults consuming controlled diets containing 1660 mg phosphorus and 420 mg calcium. Within 24 hours, the diet resulted in elevated indexes of PTH action (79) that persisted for four weeks (80). Animal data confirm that the combination of high phosphorus and low calcium diets is deleterious to bone mass (81). However, it is difficult to differentiate the detrimental effects of low calcium from that of high phosphorus (78).

Human studies using calcium kinetic methodology showed no effect on bone turnover from doubling phosphorus (82), a conclusion supported by a non isotopic study done in young women (83). The phosphorus intake typically consumed in the US diet probably does not adversely affect bone health (84).

One issue is the potential adverse effects of the consumption of carbonated beverages. Some studies have shown decreased bone mass and elevated fracture rates with the consumption of carbonated beverages (85), while others have not shown such a relationship (86). A possible explanation for the adverse effect of carbonated beverages on bones could be due to the resulting acid load caused by the ingestion of phosphoric acid used as an acidulant (78). However, the adverse effects may simply due to the displacement of milk from the diet and thus to lower calcium intake, rather than to any other plausible mechanism (78).

Magnesium

There are approximately 25 grams of magnesium (Mg) in the human body, two thirds of which are in the skeleton and the rest in soft tissue. The Mg in bone is not the integral part of the hydroxyapatite crystal structure (like calcium and phosphorus); rather, it is absorbed on the surface of the crystal (78). Only a small fraction of Mg in bone is freely exchangeable with extra cellular Mg (87); however, it plays an important role in calcium and bone metabolism.

Animal studies show that Mg deficiency results in decreased bone strength and volume, poor bone development (88) and uncoupling of bone formation and resorption (89). For these reasons, it is thought that Mg deficiency may be a risk factor for osteoporosis (78). Consistent with the animal studies, numerous populations' studies demonstrate a positive association between magnesium intake and BMD (90).

National surveys consistently show low intakes of Mg among females of all age groups, but particularly among teenagers (91). A recent report on Mg balance by Andon et al. (92) showed that teenage girls with low Mg intake (<177 mg/day) were in negative Mg balance. Although diets might be marginally low in Mg, we know very little about how Mg affects bone health in humans.

Iron

Iron (Fe) may play an important role in bone formation acting as a cofactor for enzymes involved in collagen synthesis (93). Bone breaking strength was lower in Fe deficient rats, suggesting that Fe deficiency may play a role in bone fragility (94). Fe absorption may be inhibited by the high intakes of other minerals and trace elements, particularly calcium. Numerous studies have shown the inhibitory effect of calcium on Fe from different supplements (salts) or calcium containing foods (95, 96).

It is not clear to what extent, if any, higher calcium intake might influence Fe stores and what would be the consequences of lower Fe stores on bone mass (78). However, there is no effect of calcium on serum ferritin in adults (96). On an opposite note, Fe might act as a toxin to bone cells and contribute to osteoporosis or other bone diseases in people with impaired Fe metabolism and Fe overload (78).

Zinc

The human body contains one to two grams of zinc (Zn) and about 90% is found in muscle, bone, skin, and hair, while blood contains less than 1%. Zn acts as a cofactor for several enzymes, such as alkaline phosphatase, which is necessary for bone mineralization, and collagens, which is essential for the development of the collagenous structure of bone (97).

Zn deficiency results in impaired DNA synthesis and protein metabolism, which led to negative effects on bone formation (97). The role of Zn in bone formation is well documented in animal models (98), and low serum levels of Zn and excessive urinary excretion are related to osteoporosis in humans (99). Although animal studies show that calcium interferes with the intestinal absorption of Zn (100), human studies are less convincing (101).

Copper

The body contains about 75 to 100 mg of copper (Cu) which is mostly accumulated during growth. Deficiency of Cu is rare as Cu is present in nearly all foods (78). Because Cu influences collagen maturation, it could influence bone composition and structure (78). Cu deficiency results in decreased bone strength in rats (94) and chicks (102).

Sodium

There is a positive relationship between urinary sodium and urinary calcium excretion. It has been repeatedly shown in animals and humans that dietary sodium, in the form of salt increases urinary calcium excretion (103). Although it is clear that sodium is an important determinant of obligatory calcium loss in urine and causes bone loss in animals (104), there are only a few studies examining its effect on bone mass in humans. One study showed that high sodium intakes (>2,000-milligrams/day) are associated with greater bone loss and reduced bone mass in postmenopausal women (105). Evans et al. (106) showed that postmenopausal, but not pre-menopausal women, responded to a one-week high sodium intake of 300 mml/day by an increase in deoxypyridinoline. Other studies evaluating the effect of dietary sodium on bone markers are inconclusive (107). Whether this same effect occurs in pre menopausal athletic women is not known and more research needs to be conducted on this population.

Caffeine

The relationship between caffeine and osteoporosis has not been thoroughly researched. It was once thought that caffeine simply increased urinary loss of calcium, and as such, was considered a risk for bone loss (78). However, the long term effect of caffeine on calcium and bone metabolism is more complex, probably affecting intestinal calcium absorption from endogenous sources (78). In an analysis of 560 balance studies carried out in 190 adult women, caffeine surprisingly does little to affect urinary calcium excretion or total calcium entry into the gut (108). One study suggests that excessive caffeine intake may have a deleterious effect on the BMD of women, even if they consume adequate amounts of calcium (109).

Other studies however, show no effect of caffeine and an increased risk for bone loss (110, 111). Epidemiological data addressing the association between coffee consumption and bone status are quite contradictory (78). There are those that show detrimental associations between caffeine consumption (112) and those that do not (113). It appears that the deleterious effect of caffeine becomes most pronounced when dietary calcium is inadequate and less harmful when dietary calcium is high (112).

Soy

Research into the health effects of soy foods and soybean constituents has increased at a phenomenal pace over the past decade; however, there are conflicting results on the role of isoflavons in bone health (114). Soy may support stronger bones by decreasing the amount of calcium lost in urine (115). However the data supporting claims that isoflavons consumption improves bone health are not as strong as data on lipid lowering and reduction of menopausal symptoms. Animal studies suggest that dietary isoflavons may exert benefits on bone mineral density (116), and bone turnover (117) but there have been very few human studies in this area.

Human studies in Japan, China, and America suggest soy's ability to maintain bone health, and possibly even improve bone health (118). Combined with calcium, regular soy intake makes a great nutritional duo to support a healthy skeletal system. Consuming soy foods in amounts that provide ~10 g/day of soy protein, which is similar to Asian intake (119) and consistent with the amount of soy associated with improved bone health (120, 121) in many epidemiological studies, holds the potential to exert health benefits while still only representing about 10-15% of total US protein intake (122).

Alcohol

Alcohol exposure increases parathyroid hormone levels (PTH) which can lead to a disruption in calcium balance (123). In cases of chronic alcohol abuse, blood levels of parathyroid hormone can remain elevated, resulting in a strain on the body's calcium reserves. In alcoholics, continuous elevations in parathyroid hormone can precipitate the condition known as secondary hyperparathyroidism, the effects of which further deplete calcium stores (123). Alcohol can also inhibit the production of enzymes found in the liver and kidney that convert the inactive form of vitamin D to its active form (123). This interference in vitamin D metabolism results in an impairment of calcium absorption. Alcohol also increases magnesium excretion, an effect that can further negatively impact bone health (123). In pre-menopausal women, chronic alcohol exposure can result in irregular menstrual cycles, an occurrence that increases osteoporosis risk.

Alcoholics have been shown to have high levels of cortisol, a corticosteroid. Excessive levels of cortisol have been linked to decreased bone formation and increased bone resorption. Corticosteroids impair calcium absorption which leads to an increase in PTH secretion, which can result in further bone loss (123). Alcohol appears to have a direct toxic effect on osteoblasts, suppressing bone formation. On the other hand, osteoclasts may be stimulated by alcohol exposure (123).

Nutrition Knowledge

Increasing nutritional knowledge in female athletes leads to better food choices, resulting in improved health status, enhanced athletic performance (5, 124-126), and more desirable attitudes toward nutrition (5, 127). Athletes are barraged with nutrition information from a variety of sources that include coaches, athletic trainers, parents, teammates, fitness trainers, supplement manufacturers, and the media (128, 129). Past studies on nutrition knowledge of athletes indicate that many athletes believe vitamin supplements are needed to improve athletic performance and provide energy (128-133), protein supplements are necessary to build muscle (128, 129, 133), and protein is the primary energy source for muscle (128, 129, 133). Studies also show that individuals who have a basic knowledge of nutrition principles apply these principles when selecting foods (37, 134, 135).

Research suggests that increasing dairy products in the diet to meet calcium recommendations greatly increases bone density in pre-menopausal women (45) which, in turn, may influence post-menopausal bone mass (136, 137). In one study, supplementation with dairy products during young adulthood prevented spine bone loss in 30-42 year old pre-menopausal women (45). Another retrospective study reported that frequent milk consumption before age 25 was a significant independent predictor of BMD at all sites (20). A cross-sectional study of 139 women aged 30-39 years used a food frequency questionnaire (FFQ) to determine the calcium intake for both the year before bone density measurements and for ages 13-17 years. Results showed that a higher lifetime of calcium intake ($\geq$828 milligrams per day currently and $\geq$1,000 milligrams per day during the teenage years) was associated with a higher hip bone density compared with a low lifetime calcium intake ($<$828 milligrams per day currently and $<$1,000 milligrams per day during the teenage years) (138).

Halioua et al. (1989) reported that in a group of 181 pre-menopausal women, intermediate or high lifetime calcium consumption (≥500 milligrams per day) was significantly correlated with greater BMC and BMD in both the distal and midshaft radial sites. The results of other investigations have indicated that a high calcium intake is associated with higher bone densities in women of various ages (17, 20, 35, 39, 43, 44, 47, 48, 60, 105, 136, 137, 139).

The results of these studies and others illustrate the need to educate female athletes on the protective element of a high calcium diet. The foods that contain the highest amounts of calcium are dairy products; unfortunately, many female athletes perceive these as fattening and omit them from their diets in their attempts to lose weight. There is a great need in this population for guidelines and easy to use assessments that can help in the education and improvement of nutritional status.

CHAPTER 3

A NUTRITION ASSESSMENT FOR COACHES AND ATHLETES

This assessment will provide tools that coaches can use to help evaluate the dietary practices of athletes, or that you, the athlete, can use to evaluate your nutritional status. The assessment will help you to understand why and how to change poor dietary behaviors and begin to choose foods that will help to increase calcium intake and potentially improve bone health.

This assessment may help to diminish false beliefs that coaches may have regarding dietary practices so that they provide information to you with confidence. Thus, this project offers you an evaluative assessment of your dietary habits. With this information, you and your coach can work toward improving nutritional status and bone health.

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I. DIET ASSESSMENTS

Dietary Calcium Checklist

The next few pages will help you to understand more about how you usually eat and how your can make changes to keep increase your calcium intake. All of us could probably eat at least a little better than we do now. It's tempting to want to answer these questions the way you would like to eat or feel you should eat. BUT, the best way for you to improve your health is to take a good honest look at how you're eating now and then start working on some positive changes. The questionnaire asks questions about the foods that you eat; it focuses on foods that contain high amounts of calcium for improving bone health and other key nutrients that effect bone health such as protein and soy. You can take this questionnaire at the beginning and end of the season and/or year to determine if your eating habits have improved. The questionnaire will also help to determine if you are at a high risk for osteoporosis (140-142). Osteoporosis is linked to heredity, ethnicity, activity level, and many other factors, which means that you may be at risk even if you consume adequate amounts of calcium in your diet or through supplements.

How do I fill out this questionnaire?

In the food groups below, fill in the total number of servings that you have eaten of each of the following foods in the past **seven** days. Serving sizes have been provided when needed. Parts of this questionnaire have been adapted from Ward et al., 2004 and A New Leaf: Choices for Healthy Living, University of North Carolina at Chapel Hill (143).

In the last seven days, how many times have you had the following foods?

Milk, Yogurt, & Cheese	**total # of servings**	**x**	**mgs calcium**
Cheese, 1 oz or 6 tbsp		x 200	
Cottage cheese, ½ cup		x 50	
Custard, pudding, or cream pie, ½ cup		x 150	
Ice cream, frozen yogurt, or milk shake, 1 cup		x 200	
Milk or cocoa, 1 cup		x 300	
Soy milk, 1 cup		x 10	
Yogurt		x 350	
Cream soups/sauces, 1 cup		x 200	
Macaroni & cheese, 1 cup; pizza, 1/8 of 15"; or quiche, 1/8 of 8"		x 250	
Milk Total	***servings:***		***mg:***

Fruits & Vegetables	**total # of servings**	**x**	**mgs calcium**
Broccoli or cooked greens (beet/turnip greens, kale, collards, spinach), ½ cup		x 100	
Potato, 1 medium		x 20	
Other vegetables, ½ cup		x 30	
Fruits, ½ cup or 1 small		x 30	
Calcium supplemented orange juice, 8 oz		x 300	
Fruit & Vegetable Total	***servings:***		***mg:***

Breads & Cereals	**total # of servings**	**x**	**mgs calcium**
Bread, 1 slice; or cereal, 1 oz		x 20	
Calcium supplemented bread, 1 slice		x 290	
Calcium supplemented bread, light, 1 slice		x 145	
Bagel, 1 medium, all varieties		x 53	
2" biscuit/roll, or 6" tortilla, or 3" muffin, cornbread, or doughnut		x 40	
Rice, noodles, or pasta, 1 cup		x 20	
Pancake, waffle, or French toast, 2 pieces		x 100	
Bread & Cereal Total	***servings:***		***mg:***

Meat, Fish, Poultry, & Beans	**total # of servings**	**x**	**mgs calcium**
Dried beans, cooked, (navy, pinto, kidney), 1 cup		x 50	
Meat, fish, poultry, 3 oz		x 10	
Peanuts, ½ cup in shell; 1 egg		x 30	
Salmon w/ bones, 3 oz		x 150	
Sardines w/ bones, 3 oz		x 400	
3 oz shrimp; or 7-9 oysters		x 100	
Tofu, 2 ½" x 2 ½" x 1"		x 100	
Meat Total	***servings:***		***mgs:***

Fat, Sugar, & Alcohol	**total # of servings**	**x**	**mgs calcium**
Cake, 1/16 of 9" cake*		x 40	
Beer, 12 oz*		x 10	
Colas, 12 oz*		x 10	
Chocolate, 1 oz*		x 50	
Other Total	***servings:***		***mgs:***

Are you taking any additional vitamin/mineral supplements?	**Yes**	**No**
If yes, list type:		
How often did you take this supplement in the last seven days?		
How many days in the last week did you spend at least 10min in the sun (doesn't have to be at one time)?		
Do you smoke cigarettes?	**Yes**	**No**
Has anyone in your family been diagnosed w/ osteoporosis?	**Yes**	**No**

*Although these foods have small amounts of calcium in them, it is recommended that you consume them in moderate amounts to avoid the other negative effects. Adults should consume only about 30% of their calories from fats, limit their intake of simple sugars, and consume approximately one alcoholic drink per day.

Scoring:

In each section above, multiply the total # of servings of each food **x** the corresponding calcium intake value. Add the total number of servings, and then add the total mg calcium for each food group. Transfer those numbers to the following chart;

	total # of servings	**milligrams calcium**
Milk, Yogurt, & Cheese		
Fruits & Vegetables		
Breads & Cereals		
Meat, Fish, & Poultry		
Fat, Sugar, & Alcohol		
Total Calcium Intake for Past Week =		

Next, divide your total calcium intake by 7 to get average daily intake for the past week;

Total Calcium Intake/7 = _____ *mg per day*

How does your diet add up?

If your total calcium intake is 1000 mg/day or more you are eating recommended amounts of calcium containing foods or taking a supplement and reducing your risk for osteoporosis. You have made a lifestyle change that is improving your bone health. You balance your diet with foods that are high in calcium and moderate in protein and caffeine.

If your calcium intake is less than 1000 mg/day you need to increase your calcium intake. Try eating leafy green vegetables or more dairy foods to increase calcium intake. If you need more calcium you could also consider a calcium supplement. You may be consuming a diet that is too high in caffeine and protein. It is okay to cut some protein out and replace it with high calcium foods to support bone health.

Meat and eggs have lots of phosphorus which keeps your body from getting the calcium it needs. You should be eating two or more servings of calcium containing foods like milk, cheese, yogurt or other dairy foods daily. If you are not getting enough calcium talk with your team physician or dietitian about a calcium supplement. Make sure that you are spending between 10-15 min in the sun 3-4 times per week. If you smoke talk with your team doctor to find ways to quit, smoking can make your bones weak. You may have heard about osteoporosis but think that you are not at risk. Unfortunately, you may be at the highest risk and should begin to make changes that will increase your calcium intake to prevent stress fractures and osteoporosis. You may want to talk to your doctor or team physician about getting a bone density scan to determine if you have a low bone mineral density and are at risk for stress fractures and osteoporosis. Remember to stay positive and ask for help, it may be possible for you to increase your bone density by increasing your calcium intake by eating more calcium rich foods or taking a calcium supplement.

Three-Day Food Record

Another way to determine your dietary needs is by recording a three-day food record and entering this information into a dietary assessment database such as Diet Analysis Plus. This will give you an idea of how many calories you are consuming as well as the nutrients you need especially calcium. The results will help you to see where your diet could use some improvement.

For example, the following information is from Diet Analysis Plus for an individual who is an extremely active 20 year old female who weighs 130 lbs, stands 5'10" tall, and has a BMI of 19.

Recommended Daily Nutrients

Calories	*2993 kcals*
Protein	*90 grams*
Carbohydrates	*434 grams*
Dietary Fiber	*30 grams*
Total Fat	*100 grams*
Saturated Fat	*30 grams*
Monounsaturated Fat	*37 grams*
Polyunsaturated Fat	*33 grams*
Cholesterol	*300 milligrams*
Vitamin A	*800 RE*
Thiamin – Vitamin B1	*1 milligram*
Riboflavin – Vitamin B2	*1 milligram*
Niacin – Vitamin B3	*14 milligrams*
Vitamin B6	*1 milligram*

Vitamin B12	*2 micrograms*
Folate	*400 micrograms*
Vitamin C	*75 milligrams*
Vitamin D .	*5 micrograms*
Vitamin E – Alpha Equivalent	*15 milligrams*
Calcium	*1000 milligrams*
Iron	*15 milligrams*
Magnesium	*310 milligrams*
Phosphorus	*700 milligrams*
Potassium	*3500 milligrams*
Sodium	*2400 milligrams*
Zinc	*12 milligrams*

Below is a list of food that might be consumed by an athlete;

Serving Size	***Food Item***
1 cup	*Fresh Orange juice*
1 ½ cup	*Kellogg's Raisin Bran Cereal*
1 cup	*1% Lowfat Milk*
3 oz	*Tuna in water*
2 tbs	*Mayonnaise*
1 piece	*Romaine lettuce*
¼ piece	*Tomato*
2 slices	*Whole wheat bread*
1 medium	*Apple*

3 cups	*Microwave popcorn*
2 cups	*Noodles*
3 oz	*Ground beef*
½ cup	*Tomato sauce*
2 tbs	*Grated Parmesan cheese*
1.5 cups	*Tossed green salad*
2 tbs	*French dressing*
1 cup	*Nonfat frozen yogurt (chocolate)*

Below is a table that shows how much of each of the nutrients is contained in the sample diet and what percent of the recommended goal it has achieved;

Nutrient	***Value***	***% of Recommended Goal***
Calories	*2113 kcals*	*71%*
Water	*1384 grams*	
Protein	*106 grams*	*118%*
Carbohydrates	*323 grams*	*74%*
Dietary Fiber	*36 grams*	*122%*
Total Fat	*55 grams*	*55%*
Saturated Fat	*16 grams*	*55 %*
Monounsaturated Fat	*16 grams*	*44%*
Polyunsaturated Fat	*17 grams*	*51%*
Cholesterol	*140 milligrams*	*47%*
Vitamin A	*1155 RE*	*144%*
Thiamin – Vitamin B1	*2 milligrams*	*194%*

Riboflavin – Vitamin B2	*3 milligrams*	*233%*
Niacin – Vitamin B 3	*35 milligrams*	*248%*
Vitamin B6	*2 milligrams*	*167%*
Vitamin B12	*9 micrograms*	*389%*
Folate	*630 micrograms*	*158%*
Vitamin C	*172 milligrams*	*229%*
Vitamin D	*8 micrograms*	*159%*
Vitamin E – Alpha Equivalent	*8 milligrams*	*53%*
Calcium	*1028 milligrams*	*103%*
Iron	*22 milligrams*	*148%*
Magnesium	*481 milligrams*	*155%*
Phosphorus	*1726 milligrams*	*247%*
Potassium	*3670 milligrams*	*105%*
Sodium	*2809 milligrams*	*117%*
Zinc	*20 milligrams*	*165%*
Caffeine	*6 milligrams*	

Diet Analysis Plus breaks down the foods further give sources of calories and fats, exchanges, and ratios. Below is a table of all this information;

Source of Calories	***Percent***
Protein	*19%*
Carbohydrates	*58%*
Total Fat	*22%*
Source of Fat	***Percent***

Saturated (7-10%)	*7%*
Monounsaturated (10-15%)	*7%*
Polyunsaturated (up to 10%)	*7%*
Other / Missing	*2%*
Exchanges	***Amount***
Bread / Starch	*11.0*
Other Carbohydrates / Sugar	*2.9*
Very Lean Meat / Protein	*2.8*
Lean Meat	*4.2*
Fruit	*4.6*
Vegetables	*3.9*
Milk – Skim	*1.2*
Fat	*5.9*
Ratios	
P : S (Poly / Saturated Fat)	*1.03 : 1*
Potassium : Sodium	*1.31 : 1*
Calcium : Phosphorus	*0.60 : 1*
CSI (Cholesterol / Saturated Fat Index)	*23.49*

Diet Analysis Plus also shows how many servings there are from each food group. Below is a table showing this information;

Food Group	***Servings***
Bread, Cereal, Rice, & Pasta Group (6-11 servings)	*8.5*
Vegetable Group (3-5 servings)	*3.0*

Fruit Group (2-4 servings)	*2.7*
Meat, Poultry, Fish, Dry Beans, Eggs, & Nuts Group (2-3 servings)	*2.4*
Milk, Yogurt, & Cheese Group (2-3 servings)	*2.0*
Fats, Oils, & Sweets (use sparingly)	*12.4*

As you can see analyzing a diet in a program like Diet Analysis Plus can give the athlete a very good idea of what foods they need to increase consumption of and where they could cut back.

II. ACTIVITY ASSESSMENTS

Energy Expenditure

Now that you have figured out what you are eating the other piece to balancing energy is to determine your energy expenditure. Energy expenditure is the amount of calories you use to maintain normal body functions, digest food, and engage in athletic training and events. By calculating energy expenditure you can determine the amount of calories you should be consuming to maintain, lose or gain weight, and to optimize performance. This section will provide you with quick calculations on energy expenditure and some meal ideas to balance your energy needs.

Step 1:

The first step to balancing energy output with caloric input is to determine your Basal Metabolic Rate (BMR). Your BMR is the amount of energy it takes for your body to perform everyday functions such as digesting food, thinking, and staying awake. The following equation called the Harris-Benedict equation is used to estimate your BMR.

For Women: BMR = 655 + (9.6 x wt in kg) + (1.8 x ht in cm) – (4.7 x age in yrs)

For example, a 19 year old who weighs 120lbs and is 5'5" would be the following;

BMR = 655 + (9.6 x 55kg) + (1.8 x 520cm) – (4.7 x 19) = 1554.5 kcal

Step 2:

The second step is to calculate your activity energy expenditure. Your activity energy expenditure is the amount of energy it takes to perform in your sport or to train for competition, this calculation is will be added to your BMR. Appendix A lists some physical activities and their associated energy expenditures expressed in Metabolic Equivalents (MET's) as adapted from the American College of Sports Medicine's Exercise Guidelines (144).

Step 3:

The final step to balancing energy input with energy output is to calculate how many calories are in various foods. This can be done a number of ways. First, you can use a diet assessment program like Diet Analysis Plus, to find each food and its caloric value or you can use a chart that can be found in most basic nutrition textbooks. In addition to obtaining the caloric value of foods, you can also determine the amount of nutrients that particular food has in it. If a diet assessment program was used for the three-day food record, it is recommended that it be used here again. However, if an assessment program is not available, you can refer to Appendix B, which is a list of meal ideas for athletes, it also lists the total calories and percent of carbohydrate, fat, protein, and total calcium.

Nutrition Knowledge & Portion Sizes

Now that you know how many calories you need to perform at your best, it is time to put your knowledge to good use. Many athletes who have nutritional knowledge may still get confused when looking at the food guide pyramid; for example, determining what constitutes a serving of meat or cheese. Following is a guide for determining the serving size of various 'real life' foods. This chart can be posted in your locker room or taken on trips to make it easier for you to determine how much you are eating.

Food Group & Number of Servings	***One serving is...***	***In real life...***
Bread, cereal, rice & pasta *6-11 servings*	*1 slice of bread*	*A sandwich has 2 bread servings*
	½ bagel	*Deli bagel has 4+ servings*
	1 tortilla	
	1 pancake or waffle	*2 restaurant pancakes have 4+ servings*
	1 cup ready to eat cereal	*An average bowl of cereal has 2+ servings*
	½ cup cooked cereal, rice, or pasta	*Restaurant portions of pasta have 3+ servings, not including the sauce*
	5-6 crackers	
	12 tortilla chips	*A small bag of tortilla chips has 2 servings*
Vegetables *3-5 servings*	*½ cup cooked vegetables*	*A small order of French fries has 2+ servings*
	1 cup leafy green salad	*A plate of salad has 2+ servings*
Fruits *2-4 servings*	*1 medium apple, banana, or orange*	*A bottle of juice (16-oz) has 2+ servings*
	½ cup chopped fruit	
	¾ cup fruit juice	
Milk, yogurt, & cheese *2-3 servings*	*1 cup of milk or yogurt*	*A large latte has 1 serving of milk*
	1 ½ oz cheese	*2 slices of pizza have ½ serving of cheese*
		A slice of processed cheese has ½ serving
Meat, poultry, fish, dry beans, eggs, & nuts *2-3 servings*	*2-3 oz of lean cooked meat*	*A quarter pound hamburger has about 1 ½ servings*

2 tbsp peanut butter = 1 oz *A refried bean burrito has ½ serving*

Keeping a list or chart of your food goals is a good way to make sure you are getting the recommended amounts of each nutrient. If you feel that you need to lose weight you should consult your team nutritionist or physician before embarking on any severe caloric restricting diet.

World Health Organization Criteria for the Diagnosis of Osteoporosis and Osteopenia.

Category	**Criteria (expressed as T-score)**
Normal	Patient BMD ≤ 1 SD of average peak young adult BMD (T-score, 0 to -1)
Osteopenia	Patient BMD between 1 SD and 2.5 SD below average peak young adult BMD (T-score, -1 to -2.5)
Osteoporosis	Patient BMD ≥ 2.5 SD below average peak young adult BMD (T-score, ≥ -2.5)
Severe Osteoporosis	Patient BMD ≥ 2.5 SD below average peak young adult BMD with fragility fractures

BMD = bone mineral density. Osteoporosis is diagnosed by comparing a patient's BMD (expressed as a T-score) with an average peak bone mass of young, normal adult women.

III. AFTERTHOUGHT

It is important for athletes to obtain correct information regarding proper nutrition for performance and bone health. However, because of the variety of places that athletes get their information they often omit dairy products from their diets because they are told that these foods are high in fat. Chronically low calcium intakes decrease bone mass and increases the risk for stress fractures and osteoporosis. There are many excellent food sources of calcium and young female athletes should eat a variety of these. If the food intake of calcium is too low, a calcium supplement may be warranted.

Current literature investigating calcium supplementation falls short of determining if this population would benefit from calcium supplementation. More research needs to be done in to determine if supplementing pre-menopausal female athletes with calcium increases BMD and decreases the risk of osteoporosis.

APPENDIX A

CLASSIFICATION OF ENERGY COSTS OF HUMAN PHYSICAL ACTIVITIES

The following is a table of the energy expended in various physical activities. To calculate the energy expenditure in kcal/kg body weight/hr use the following example; for a 130 pound person playing competitive volleyball in a gymnasium for 2 hours. (4 MET's x 59 kg body weight) x (120 minutes / 60 minutes) = 472 kcal. To determine the kcals expended per hour divide 472 by 120 minutes = 3.9 kcal/minute.

Major Heading	*Specific Activity*	*MET's Used*	*Intensity/Description*
Bicycling		*6.0*	*10-11.9mph, leisure, slow, light effort*
		8.0	*12-13.9mph, leisure, moderate effort*
		10.0	*14-15.9mph, racing or leisure, fast, vigorous effort*
Conditioning exercise	*Bicycling-stationary*	*3.0*	*50W, very light effort*
		5.5	*100W, light effort*
		7.0	*150W, moderate effort*
		10.5	*200W, vigorous effort*
		12.5	*250W, very vigorous effort*
	Calisthenics	*8.0*	*Pushups, pull-ups, sit-ups, heavy, vigorous effort*
	Circuit training	*8.0*	*General*
	Weight lifting	*6.0*	*Free weights, nautilus, Universal, power lifting or bodybuilding, vigorous effort*
	Health club exercise	*5.5*	*General*
	Stair-treadmill ergometer	*6.0*	*General*
	Rowing-stationary	*3.5*	*50W, light effort*
		7.0	*100W, moderate effort*
		8.5	*150W, vigorous effort*
		12.0	*200W, very vigorous effort*
	Ski machine	*9.5*	*General*
	Stretching	*4.0*	*Hatha yoga*
	Water	*4.0*	*Aerobics, calisthenics*
Dancing	*Aerobic*	*6.0*	*Ballet or modern, twist*
		5.0	*Low impact*

		7.0	High impact
Running	Jogging	6.5	General, jog/walk combination
	Running	8.0	5mph, 12min/mile
		9.0	5/2mph, 11.5min/mile
		10.0	6mph, 10min/mile
		11.0	6.7mph, 9min/mile
		11.5	7mph, 8.5min/mile
		12.5	7.5mph, 8min/mile
		13.5	8mph, 7.5min/mile
		14.0	8.6mph, 7min/mile
		15.0	9mph, 6.5min/mile
		16.0	10mph, 6min/mile
		18.0	10.9mph, 5.5min/mile
		9.0	Cross country
		8.0	In place
		15.0	Up stairs
		10.0	On a track, team practice
		8.0	Training, pushing wheelchair, marathon wheeling
Sports	Basketball	8.0	Game
		6.0	Non-game, general
		4.5	Shooting baskets
		6.5	Wheelchair
	Golf	5.5	Carrying clubs
		3.0	Miniature, driving range
		5.0	Pulling clubs
		3.5	Using power cart
	Gymnastics	40.	General
	Soccer	10.0	Competitive
		7.0	Casual, general
	Softball/Baseball	5.0	Fast or slow pitch, general
		6.0	Pitching
	Tennis	6.0	Doubles
		8.0	Singles
	Volleyball	4.0	Competitive, in gym
		3.0	Non-competitive
		8.0	Beach
Water activities	Canoeing/Rowing	3.0	2-3.9mph, light effort
		7.0	4-5.9mph, moderate effort
		12.0	>6mph, vigorous effort
		3.5	For pleasure
	Diving	3.0	Springboard or platform
	Skiing	6.0	Water
	Swimming	10.0	Laps, freestyle, fast vigorous effort
		8.0	Laps, freestyle, slow,

			moderate or light effort
		8.0	*Backstroke*
		10.0	*Breaststroke*
		11.0	*Butterfly*
		11.0	*Crawl, fast, 75yards/min, vigorous effort*
		8.0	*Crawl, slow, 50yards/min, moderate or light effort*
		6.0	*Lake, ocean, river*
		8.0	*Sidestroke*
		8.0	*Synchronized*
		10.0	*Treading water, fast, vigorous effort*
		4.0	*Treading water, moderate effort*
	Water polo	*10.0*	
	Water volleyball	*3.0*	
Winter activities	*Skating*	*5.5*	*Ice, 9mph or less*
		7.0	*Ice skating, general*
		9.0	*Ice, rapidly, more than 9mph*
		15.0	*Speed, competitive*
	Ski jumping	*7.0*	*Climb up carrying skis*
	Skiing	*7.0*	*Cross country, 2.5mph, slow or light effort, ski walking*
		8.0	*Cross country, 4-4.9mph, moderate speed and effort*
		9.0	*Cross country, 5-7.9mph, brisk speed, vigorous effort*
		14.0	*Cross country, >8mhp, racing*
		16.5	*Cross country, hard snow, uphill, maximum*
		5.0	*Downhill, light effort*
		6.0	*Downhill, moderate effort*
		8.0	*Downhill, vigorous effort, racing*

APPENDIX B

MEAL IDEAS

An athlete during training or competition could easily require more than 3000 Calories per day. To meet this need, the athlete can choose a variety of nutrient-dense foods. Athletes who train exhaustively for endurance events will want to aim for a high carbohydrate intake.

Breakfast:
1 egg, fried w/ 1 tbsp butter
1 slice whole-wheat toast
2 tsp butter
2 tsp jelly
½ cup grape juice

Lunch:
Sandwich
- 2 oz turkey
- 2 slices multi-grain bread
- 1 tbsp mayo
- Lettuce leaf

1-cup green beans
2 tsp butter
½ cup strawberries
2 tbsp whipping cream
1 tsp sugar
½ cup low fat milk

Snack:
3 cups popcorn
1 kiwi

Dinner: 3 oz roast beef
½ cup rice
2 tsp butter
½ cup applesauce
1 cup iced tea
2 tsp sugar

Total kcal: 1900
46% kcal from carbohydrate
38% kcal from fat
16% kcal from protein
600 mg calcium

Breakfast: 1 cup orange juice
½ cup oatmeal
½ cup milk
1 egg
1 tsp butter

Lunch: Sandwich
2 oz roast beef
2 slices multi-grain bread
Lettuce leaf
1 tsp mayo
1-cup cole slaw
1 cup cinnamon applesauce
½ cup milk

Snack: 2 oz fudge
1-cup low fat milk

Dinner: 2 oz baked chicken
½ cup mashed potatoes
1-cup broccoli
1 whole grain dinner roll
1 tsp butter
1-cup fruit cocktail
½ cup low fat milk

Total kcal: 2100
56% kcal from carbohydrate
28% kcal from fat
16% kcal from protein
1100 mg calcium

Breakfast: ¾ cup cantaloupe
½ cup all bran cereal
1-cup low fat milk
1 slice whole-wheat toast
1 tsp butter

Lunch: 3 oz broiled chicken breast
1 small baked potato
1 cup tossed green salad
1 hard roll
2 tsp butter
2 tsp low fat dressing
1-cup low fat milk
1 small banana

Dinner: 3 oz baked flounder
1-cup brown rice
1-cup broccoli
1 hard roll
2 tsp butter
1 medium orange

Total kcal: 2100
62% kcal from carbohydrate
18% kcal from fat
20% kcal from protein
1100 mg calcium

Breakfast: 1 soft cooked egg
½ cup dry cereal
4 oz orange juice
1 slice whole-wheat toast
½ tsp butter
1-cup low fat milk

Lunch: 3 oz broiled chicken
½ cup rice
½ cup green beans
1 tsp butter
Tossed salad
1-cup spinach
½ cup onions
1 oz grated American cheese
1 tbsp low fat French dressing
Fresh apple
1 cup iced tea, sugar

Dinner: 3 oz lean roast beef
½ cup mashed potatoes
½ cup peas
1 slice multi-grain bread
1 tsp butter
1 peach
1-cup low fat milk

Snack: Fruit ice

Total kcal: 2200
59% kcal from carbohydrate
22% kcal from fat
19% kcal from protein
1300 mg calcium

Breakfast: 1 cup of orange juice
1 ½ cup raisin bran
1-cup low fat milk

Lunch: Tuna fish sandwich:
3 oz tuna
2 tbsp mayonnaise
Lettuce leaf
1 tomato slice
2 slices whole wheat bread
1 medium apple

Snack: 3 cups microwave popcorn

Dinner: 2 cups spaghetti
1-cup meat sauce
3 oz lean ground beef
½ cup of tomato sauce
2 tbsp Parmesan cheese
1 ½ cup salad
2 tbsp dressing

Dessert: 1-cup chocolate frozen yogurt

Total kcals: 2400
59% kcal from carbohydrate
22% kcal from fat
19% kcal from protein
1000 mg calcium

Breakfast: 2 medium bran muffins
2 tsp butter
1-cup vanilla yogurt
½ cup fresh strawberries
1 cup orange juice

Snack: 1 medium apple

Lunch: Sandwich

2 oz ham

1 oz Swiss cheese

2 slice rye bread

2 tsp mayo

Lettuce

1 ¼ cup salad

Lettuce, tomatoes, carrots

1 tbsp salad dressing

1-cup low-fat milk

Snack: 1-cup low fat milk

3 oatmeal cookies

Dinner: Chicken cacciatore

4 oz chicken

¾ cup stewed tomatoes

1-cup rice

¾ cup summer squash

1 ½ cup salad

Spinach, onions

1 tbsp salad dressing

2 slices Italian bread

2 tsp butter

1-cup low fat milk

Total kcal: 2500

50% kcal from carbohydrate

30% kcal from fat

20% kcal from protein

2000 mg calcium

Breakfast: 1 English muffin
2 tablespoons peanut butter
1-cup low-fat vanilla yogurt
½ cup fresh strawberries
1 cup orange juice

Snack: 1 cup cranberry juice
1-ounce pretzels

Lunch: Sandwich;
Tuna salad, whole wheat bread
½ carrot, sticks
1-cup low-fat milk

Dinner: Chicken cacciatore
4 ounces chicken
¾ cup stewed tomatoes
1-cup rice
¾ cup summer squash
1 ½ cup salad
Spinach, onions
1-tablespoon salad dressing
2 slices Italian bread
2 teaspoons butter
1-cup low-fat milk

Snack: 1-cup low-fat milk
3 oatmeal cookies

Total kcals: 2500

55% kcal from carbohydrate

25% kcal from fat

20% kcal from protein

1900 mg calcium

Breakfast:	1-cup multigrain cereal
	½ banana
	1-cup low fat milk
	½ grapefruit
	2 slices whole-wheat toast
	2 tbsp peanut butter
Lunch:	1-cup black bean soup
	3 oz broiled chicken
	½ cup steamed broccoli
	½ cup baked sweet potatoes
	1 fresh pear
	1 whole-wheat dinner roll
	1 tsp butter
	1 cup iced tea, sugar
Dinner:	3 oz baked fish
	1 baked potato w/ skin
	½ cup peas
	1 whole-wheat dinner roll
	2 tsp butter
	1 piece carrot cake
	1-cup low fat milk
Snack:	3 cups popcorn
	1-cup tomato juice

Total kcal: 2800

55% kcal from carbohydrate

28% kcal from fat

17% kcal from protein

1100 mg calcium

Breakfast:

½ cup bran cereal
1-cup nonfat milk
1 bagel (2 oz)
3 tsp butter
1 banana

Lunch:

1-cup pasta
- ½ cup spaghetti sauce
- 2 oz meatballs
- 2 tbsp grated Parmesan cheese

1 ½ cup broccoli
2 tsp butter
17 small grapes
1-cup low fat milk

Snack:

1 fat free granola bar
2 tbsp peanut butter
1 small apple

Dinner:

4 oz grilled salmon
2/3-cup rice
1 whole-wheat roll
1 cup cooked carrots
1 tsp butter
1 cup mixed green salad
Salad dressing
    2 tsp olive oil
    2 tsp wine vinegar
1 cup diced cantaloupe
1-cup low fat milk

Snack:

¼ cup low fat cottage cheese
1-cup fruit cocktail
1 small frosted cupcake
1-cup low fat milk

Total kcal: 3200

52% kcal from carbohydrate

30% kcal from fat

18% kcal from protein

1900 mg calcium

Breakfast:

1 cup shredded wheat
1 cup 1% low-fat milk
1 small banana
2 slices whole-wheat toast
4 teaspoons jelly
1 ½ cup orange juice

Lunch:

2 turkey sandwiches

1 ½ cups 1% low-fat milk

Large bunch of grapes

Snack:

3 cups plain popcorn

A smoothie made from;

1 ½ cup apple juice

1 ½ frozen banana

Dinner:

Salad;

1-cup spinach, carrots

½ cup garbanzo beans

1 tablespoon sunflower seeds

1-tablespoon ranch salad dressing

1-cup spaghetti with meat sauce

1-cup green beans

1 corn on the cob

2 slices Italian bread

4 teaspoons butter

1 piece angle food cake

1 ¼ cups fresh strawberries

1 tablespoons whipping cream

1 cup 1% low-fat milk

Total kcals: 3300

63% kcal from carbohydrate

22% kcal from fat

15% kcal from protein

2100 mg calcium

APPENDIX C

CALCIUM IN SELECT FOODS

Food	*Serving Size*	*Calories*	*Calcium*
Yogurt, plain	*1 cup low fat*	*155*	*450mg*
Sardines w/ bones	*3 oz canned*	*176*	*425mg*
Swiss cheese	*1 ½ oz*	*160*	*410mg*
Cheddar cheese	*1 ½ oz*	*171*	*305mg*
Milk	*1 cup 2%*	*121*	*295mg*
Molasses, blackstrap	*1 tbsp*	*47*	*175mg*
Tofu, soybean curd	*½ cup*	*76*	*135mg*
Pudding	*½ cup*	*162*	*145mg*
Tortilla, flour	*1 10" round*	*234*	*95mg*
Ice cream	*½ cup*	*133*	*85mg*
Bok choy	*½ cup, cooked*	*10*	*60mg*
Cottage cheese	*½ cup 2%*	*101*	*70mg*
Almonds	*1 oz*	*167*	*74mg*
Beef bologna	*2 1 oz slices*	*143*	*24mg*

APPENDIX D

THREE-DAY FOOD RECORD

Name: _____ Date: _____

Age: _____ Sex: _____ Height: _____ Weight: _____

Please fill out this food record as completely as possible. Use the following information as a guide.

In general:

Record foods in teaspoons, tablespoons, or portions of cups.

Sandwiches: list all ingredients.

Include all condiments used on or in foods.

Beverages:	Indicate whether juice is fresh, frozen, or canned. Specify other beverages (i.e. sports drinks, regular, or diet soda). Specify milk as skim, 1%, 2%, whole or other.
Fruits:	Indicate whether fruit is fresh, frozen, canned, or dried. If fruit is canned, include if it is packed in heavy or light syrup.
Vegetables:	Indicate whether fresh, frozen, or canned. Record the preparation method.
Starches:	Use brand names as much as possible. For cooked cereals—record plain oatmeal or flavored. Record dry cereals in portions of cups. For rice and pasta, indicate type and record in portions of cups. Breads: Indicate white, wheat, rye, etc.
Meats/Dairy:	Give size in inches or weight in ounces after cooking meats. Give sizes in inches or weight in ounces for cheese. Shredded cheese—record in portions of cups. For butter or margarine—record type and amount.
Eggs:	Record as soft or hard cooked, fried, scrambled, poached, or omelet.

Desserts: List commercial brand or "homemade".
For purchased candy list brand name and amount.

Examples:

1 cup Raisin Bran
1 cup 1% milk
½ cup juice
1 peach
½ cup broccoli
2 squares graham crackers
3 ounces grilled chicken breast
1 cup brown rice
16 oz water
Sandwich:
2 slices whole wheat bread
2 oz Healthy Choice turkey breast
1 slice American cheese
1-tablespoon mayo

Type of Food	Portion Size	Meal/Snack	How Prepared

Type of Food	Portion Size	Meal/Snack	How Prepared

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